



(19)

Europäisches Patentamt
European Patent Office
Office européen des brevets



(11)

EP 0 831 987 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:
12.03.2003 Bulletin 2003/11

(51) Int Cl.7: **B29C 70/36, B29C 70/44,
B29C 43/02, B29C 43/36**

(21) Application number: **96921312.3**

(86) International application number:
PCT/US96/09171

(22) Date of filing: **04.06.1996**

(87) International publication number:
WO 96/040488 (19.12.1996 Gazette 1996/55)

(54) PRODUCTION OF COMPOSITE STRUCTURES**HERSTELLEN VON VERBUNDSTRUKTUREN****PRODUCTION DE STRUCTURES COMPOSITES**

(84) Designated Contracting States:
**AT BE CH DE DK ES FI FR GB GR IE IT LI NL PT
SE**

(30) Priority: **07.06.1995 US 475849
07.03.1996 US 612251**

(43) Date of publication of application:
01.04.1998 Bulletin 1998/14

(73) Proprietors:
• **SCRIMP SYSTEMS, L.L.C.**
Warren, RI 02885 (US)
• **Hardcore Du Pont Composites, L.L.C.**
New Castle, DE 19720 (US)

(72) Inventors:
• **TUNIS, George, C., III**
Wilmington, DE 19808 (US)
• **SEEMANN, William, H., III**
Pass Christian, MS 39571 (US)
• **PERRELLA, Andrew, P.**
Hockessin, DE 19707 (US)

• **HARALDSSON, Rikard, K.**
Elkton, MD 21921 (US)
• **EVERITT, William, E.**
Hockessin, DE 19707 (US)
• **PEARSON, Everett, A.**
Warren, RI 02885 (US)

(74) Representative:
Smulders, Theodorus A.H.J., Ir. et al
Vereenigde
Postbus 87930
2508 DH Den Haag (NL)

(56) References cited:

EP-A- 0 491 650	US-A- 4 188 428
US-A- 4 217 157	US-A- 4 676 041
US-A- 4 902 215	US-A- 4 942 013
US-A- 5 045 251	US-A- 5 052 906
US-A- 5 129 813	US-A- 5 132 069
US-A- 5 304 339	US-A- 5 316 462
US-A- 5 344 601	

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 0 831 987 B1

Description

FIELD OF THE INVENTION

[0001] This invention relates to the production of fiber reinforced resin composite structures, and in particular to processes for vacuum assisted resin transfer molding of large composite structures.

BACKGROUND OF THE INVENTION

[0002] Vacuum assisted resin transfer molding (VA-RTM) has been used to produce a number of large, fiber reinforced composite structures such as boat hulls which incorporate materials such as foam and balsa cores. The cores are covered with a fiber reinforced resin. In the VA-RTM process, the reinforcement fiber, such as a fabric or mat, is arranged in a single sided mold in a dry condition along with the desired core materials according to the form of the desired finished part. The lay-up is then encapsulated in a vacuum bag and impregnated with resin under vacuum. The resin is allowed to cure.

[0003] Various methods have been utilized to introduce and enhance the distribution of resin through the reinforcement fiber. These methods include the placement of a disposable distribution media over the outside layer of fabric and the incorporation of holes and/or slots penetrating through the core to allow resin to flow from the outer to the inner layer of reinforcement fiber. See, for example, U.S. Patent Nos. 5,316,462 and 4,560,523. A supply groove in a foam core has also been used in a closed mold resin injection process to facilitate resin flow. See, for example, U.S. Patent No. 5,096,651.

[0004] In addition, US 5 304 339 teaches a feeder channel as a slot in the core's surface that is completely surrounded by the lay-up. A distribution network is placed on top of the fiber lay-up instead of in direct communication with the distribution channel. The distribution network has a larger cross-sectional area than the feeder channel.

[0005] US 5 052 906 does not teach the use of a core, but has the resin introduced through the mold to a distribution network having cross channels of approximately the same cross-sectional area. A vacuum is drawn from the outer side of the lay-up through a second distribution channel.

[0006] US 5 316 462 does not teach the use of a core. In addition, the resin is introduced through the bag to a distribution network on top the fiber lay-up through which the resin is drawn to the mold.

[0007] US 4 902 215 does teach the use of a core, but does not teach a distribution network between the surface of the core and the fiber lay-up. In addition, the feeder channel feeds the resin through the bag to the fiber lay-up and through the fiber lay-up to the core.

SUMMARY OF THE INVENTION

[0008] The present invention relates to a method according to claim 1 for distributing resin during the manufacture of a composite structure using a vacuum assisted resin transfer molding (VA-RTM) process and to a method according to claim 23. The composite structure is formed from internal cores surrounded by fiber reinforced resin. In one embodiment of the invention, resin is supplied directly into a network of main feeder grooves which are interconnected to a series of smaller microgrooves formed in the surface of the internal cores. From the feeder grooves and microgrooves, the resin flows outwardly from the core to penetrate the reinforcement fiber. In a second embodiment of the invention, a separate distribution medium is interposed between the internal core and the fiber reinforcement. The resin is supplied directly to one or more main feeder grooves in the core surface and penetrates the reinforcement fiber via the distribution medium. Also, the main feeder grooves can extend around the cores to form supply loops, allowing impregnation of transverse structural members.

[0009] In a further embodiment, an integrated vacuum bag and mold are formed from a textured sheet of metal. The texture is formed by closely spaced upraised portions on one side of the sheet which correspond with depressions on the other side of the sheet. The closely spaced upraised portions define valleys therebetween which form a resin distribution network. Main feeder grooves are formed directly in the sheet. The textured sheet can also be used as a mold from which other tools are made.

[0010] With this method, large composite structures which require multiple cores can be formed quickly prior to the gel time of typical vinyl ester or polyester resins, and the amount of resin used can be minimized. By supplying the resin directly through the vacuum bag into the feeder grooves, the supply is not limited to a part edge or inlet in a tool. Adjacent cores can be supplied via a single resin inlet. The resin distribution network can remain in the finished part, eliminating disposal of distribution materials. In this case, the microgrooves are filled with resin after curing, thereby increasing interlaminar shear strength and delamination strength. Structural features such as shear ties, compression webs, or beams can be incorporated directly into the composite part during the molding process. Further embodiments are recited in the dependent claims.

DESCRIPTION OF THE DRAWINGS

[0011] The invention will be more fully understood from the following detailed description taken in conjunction with the accompanying drawings in which:

Fig. 1 is a perspective view of a core for a composite structure according to a first embodiment of the

present invention;

Fig. 2 is a schematic cross-sectional view of a composite structure being formed according to the first embodiment of the present invention;

Fig. 3 is a schematic perspective view of a further composite structure being formed according to the present invention;

Fig. 4 is a perspective view of a composite structure being formed according to the present invention;

Fig. 5 is a perspective view of a further core for a composite structure according to the present invention;

Fig. 6 is a perspective view of a core for a composite structure according to a second embodiment of the present invention;

Fig. 7 is a schematic cross-sectional view of a composite structure being formed according to the second embodiment of the present invention;

Fig. 8 is a schematic cross-sectional view of a composite structure being formed using an integrated mold and vacuum structure;

Fig. 9 is a schematic cross-sectional view of a rigid mold and flexible lid for forming a composite structure;

Fig. 10 is a perspective view of a core for a composite structure having multiple main feeder grooves;

Fig. 11 is a schematic cross-sectional view of an integrated mold and vacuum bag for forming a composite structure according to a further embodiment of the present invention;

Fig. 12 is a perspective view of one side of a textured sheet of material forming the integrated mold and vacuum bag of Fig. 11; and

Fig. 13 is a perspective view of the other side of the textured sheet of Fig. 12.

DETAILED DESCRIPTION OF THE INVENTION

[0012] A large composite part made according to the present invention includes a core 12, shown in Fig. 1. The core is made from a material able to support the pressure of a vacuum. Typical materials include foams, such as a polyurethane or a polyvinyl chloride, or balsa wood. The core can be solid or hollow, such as a blown polyethylene. Concrete may also be used. The core is shown as a rectangular block, although other configurations are possible, as discussed further below.

[0013] One or more main feeder grooves or channels 14 are provided in the surface 16 of the core. The main feeder groove may circumscribe the entire core to form a loop. A resin distribution network comprising channels of a smaller cross-sectional area than the main feeder groove is provided in contact with the surface of the core for fluid communication with the main feeder groove.

[0014] In a first embodiment of the present invention, the resin distribution network is provided in the form of a plurality of microgrooves 18 machined in the surface

16 of the core 12, as shown in Fig. 1. The microgrooves 18 are generally arranged transversely to the main feeder groove 14. Some of the microgrooves may circumscribe the entire core to create a resin flow loop beginning and ending at the main feeder groove. The actual relation of the microgrooves to the main feeder groove depends on the geometry of the core and the optimization of the resin impregnation, as discussed further below.

[0015] The core 14 with the network of grooves is covered with one or more layers of a fiber material 20, illustrated schematically in Fig. 2. The fiber material may be a cloth or mat formed from fibers of glass, carbon, or other suitable material. Depending on the structural requirements of the desired finished part, the core may be completely surrounded with fiber material, or one or more surfaces of the core may be left free of fiber material. The fiber material may be wrapped in a sheet around the core, or individual pieces of fiber material may be applied to the desired core faces. The fiber may also be supplied in a tubular form into which the core is inserted.

[0016] A plurality of fiber wrapped cores are arranged to form the desired finished part. Although two cores are shown in Fig. 2, the actual number and arrangement of cores is determined by the desired finished part. One or more layers of a fiber material can be wrapped around a plurality of cores to form an outer skin 22, shown schematically in Fig. 2. The particular number of layers of fiber material, the type, and the arrangement depend on the desired finished part and can be readily determined by those of skill in the art. A bleeder layer is generally provided in the form of a tab 23 extending from an outer fiber layer to a vacuum outlet 25. Peel plies, typically required with prior art vacuum processes, are generally not needed with the process of the present invention.

[0017] The fiber material 24 surrounding and between the cores creates structural members such as shear ties, compression webs, and beams. For example, referring to Fig. 4, a plurality of triangular cores 40 are used to form a deck. The fiber material between adjacent triangular cores forms diagonal structural members 41 that support both compression and shear forces.

[0018] During the lay-up, suitable fittings 26, such as plastic or copper tees, are positioned in the main feeder grooves 14 to facilitate the subsequent insertion of resin supply tubes 28. One or more fittings may be positioned in each feeder groove, to accommodate the desired resin flow. The lay-up is placed against a mold 29, and a vacuum bag 30 is then placed over the lay-up, including the plastic fittings, and sealed to the mold in a manner known in the art, as shown schematically in Fig. 2. The vacuum bag is then punctured and the supply tubes 28 are inserted through the vacuum bag directly into their respective fittings 26. The supply tubes are sealed to the bag to retain vacuum integrity. In this manner, the main feeder grooves are supplied directly with resin by penetrating the outer vacuum bag with a supply tube

that is inserted directly into the groove.

[0019] Referring to Fig. 8, the vacuum bag and mold may also be integrated into a single structure 80 which is rigid enough to retain its shape as a mold but flexible enough to collapse against the part upon application of a vacuum. For example, the integrated structure 80 may comprise a thin gauge steel sheet, such as 0.63cm (0.25 inch) or thinner. The cores 82 and fiber material 84, 86, as described above, are encapsulated in the steel sheet. Holes are drilled through the sheet to access the fittings. Resin impregnation occurs as described above. The integrated structure may be formed of other suitable materials, such as rubber or silicone or a thin composite sheet material such as a plastic laminated metal.

[0020] Fig. 9 illustrates a further mold embodiment in which a rigid mold 90 is sealed with a flexible lid 92 formed, for example, from a steel or plastic material. A part, comprising the cores and fiber material as described above, is placed in the recess 94 defined by the rigid mold. A vacuum groove 96 in the lid surrounds the part. Holes are provided through the lid or mold to access fittings for resin impregnation as described above. During impregnation of the resin under vacuum, the lid flexes at the edge of the vacuum groove, to allow compaction of the part.

[0021] The resin, such as a polyester, vinyl ester, epoxy, phenolic, acrylic, or bismaleimide, travels relatively quickly through the main feeder grooves 14 and into the microgrooves 18. From the microgrooves, the resin penetrates the fiber material 20, 22. Impregnation results from resin infusion originating at the core surface 16 and migrating outwardly to the exterior of the part. The fiber material on adjacent core surfaces may be impregnated via a main feeder groove in one of the adjacent cores, as indicated in Figs. 3 and 4.

[0022] The cross-sectional area of the main feeder groove and the cross-sectional area and spacing of the microgrooves are optimized to provide a suitable time to allow the resin to impregnate all of the fiber material before curing without leaving unimpregnated areas. A typical main feeder groove may have a depth of 0.5 inch (13mm) and a width of 0.5 inch (13 mm) for a cross-sectional area of 0.25 square inches (161 square mm). Typical microgrooves may have a depth of 0.125 inch (3.2mm) and a width of 0.125 inch (3.2mm) for a cross-sectional area of approximately 0.016 square inches (10 square mm). The microgrooves may be spaced 1.0 inch (25mm) on center. These dimensions may be modified to accommodate reinforcement fiber materials of different types and/or thicknesses. Also, the cross-sectional area of the main feeder grooves may be increased if the part is particularly large to more rapidly distribute the resin to all sections of the part. Similarly, multiple main feeder grooves 14 may be provided in a core 12, as indicated in Fig. 10.

[0023] In addition, the cross-sectional area of the main feeder grooves or the microgrooves may be reduced to create flow restrictions to increase resin dwell

time at a particular area. Resin dwell time may also be increased by placing a resin "fuse" in the feeder groove which temporarily blocks the resin flow. The fuse dissolves after contact with the resin after a known period of time, which may be set by the length of the fuse. For example, with a vinyl ester resin, a styrofoam fuse has been used successfully. The feeder grooves may also terminate to redirect resin flow.

[0024] The main feeder grooves 14 allow passage of resin from one core to an adjacent core. Holes may be provided through the cores to connect main feeder grooves. Each main feeder groove may be supplied with resin simultaneously, creating parallel circuits, or in a prescribed sequence, creating series circuits, depending on the geometry and size of the part to be impregnated. Additionally, the main feeder grooves may be independent of each other, creating separate circuits.

[0025] After impregnation, the resin is allowed sufficient time to cure. Once cured, the microgrooves 18 are filled with solid resin. This resin provides a lateral locking mechanism which improves the interlaminar shear strength of the bond between the fiber reinforced composite and the core. The resin remaining in the groove network also increases the forces necessary to delaminate the fiber reinforced face skins from the core.

[0026] The actual arrangement and shape and number of cores depends on the desired finished part. For example, triangular cores 40 are shown in Fig. 3. The triangular cores may have main feeder grooves 42 provided in at least two surfaces. A central triangular core 44 may have main feeder grooves in three surfaces. Microgrooves are provided in the surfaces as described above. A plurality of triangular cores may be arranged in, for example, a row to form a deck. In this example, resin, supplied through tubes 46, is impregnated sequentially beginning at the central core and progressing toward the edges, as shown by the shaded region 48 in Fig. 4.

[0027] An arcuate core 50 is shown in Fig. 5. The arcuate core 50 may have a main feeder groove 52 in one surface and a network of microgrooves 54 radiating from the feeder groove to circumscribe the core. The arcuate cores may be used to form curved structures such as boat hulls or arches.

[0028] In another embodiment of the present invention, illustrated in Figs. 6 and 7, a core 60 is provided with a main feeder groove 62 as described above. A distribution medium 64 is then provided adjacent the core faces. The medium comprises a network of open passageways formed by a structure capable of maintaining the passageways in an open condition during application of the vacuum. For example, the medium may comprise intersecting filaments held in spaced relation from the core surface by post-like members located at each filament intersection, a grid-like structure of aligned strips, or an open weave fabric. Suitable distribution media are known for example, from U.S. Patents Nos. 4,902,215 and 5,052,906, incorporated herein by refer-

ence. A fiber material 66 is then wrapped over the distribution media, as described above. A plurality of cores are arranged to form the desired finished part, and a vacuum bag 68 is placed over the cores and fiber material, as described above. Resin supply tubes 70 leading from a resin source are inserted through the bag 68 and fiber material 66 to fittings 72 in the main feeder grooves 62. The supply tubes 70 are sealed to the vacuum bag in a manner known in the art. Resin is fed through the supply tubes to the main feeder grooves. The resin travels relatively quickly through the main feeder grooves and into the distribution media. From the distribution media, the resin penetrates the fiber material. A suitable time interval is provided to allow the resin to cure.

[0029] Resin distribution media presents a more uniform resin flow front than the microgrooves. For this reason, resin distribution media are generally preferred for more complicated parts, whereas microgrooves are preferred to conserve resin, since less resin flows through the microgrooves.

[0030] In a further embodiment, illustrated in Figs. 11 through 13, the vacuum bag and mold are integrated into a single tool 102 formed from a textured sheet 104 of metal, such as a thin gauge steel sheet. The sheet is rigid enough to retain its shape as a mold, but flexible enough to collapse or be pulled against the part under the vacuum applied during a resin impregnation process, discussed further below. A sheet thickness of 0.25 inch (6.4mm) or less has been found suitable. A plastic or a composite material such as a metal and plastic laminate formed as a textured sheet may also be used.

[0031] Preferably, the texture is formed by closely spaced upraised portions 108 formed on one side of the sheet 104 which correspond to depressions 106 on the other side of the sheet. The closely spaced upraised portions 108 define valleys 110 therebetween which form a resin distribution network. For example, the upraised portions may have a generally hexagonal shape having a longest dimension of between 3/8 inch (95mm) and 7/16 inch (11mm). A depth of the valleys of approximately 30 thousandths of an inch (0.76mm) has been found to be suitable. Such a textured sheet is readily formable and is commercially available from Ardmore Textured Metal of Edison, New Jersey. Alternatively, the texture could be provided on a single side of the sheet if desired, such that the upraised portions do not make corresponding depressions on the other side.

[0032] The sheet is shaped into the desired form of a mold 112 having a mold cavity 118 with the upraised portions of the sheet forming the interior walls of the cavity, thereby facing the part to be impregnated. Main feeder grooves 114 are formed directly in the sheet 104 in the desired locations, rather than in the cores as described above. The main feeder grooves may have dimensions as discussed above. Vacuum outlet channels 116 are formed around the perimeter of the tool.

[0033] To form a composite part, a fiber lay up is

placed within the cavity 118 adjacent the textured surfaces of the tool, and the tool is sealed as with a tacky tape or other seal as is known in the art. A peel ply may be used if the texture is not to be retained on the part. Alternatively, a peel ply may be omitted if the texture is desired to be retained on the surface of the part. Forming the texture on the part imparts some further stiffness to the part and may be desired for esthetic reasons as well. The fiber lay up may comprise cores wrapped with fiber material as discussed above. Fittings are inserted into the main feeder grooves through punctures made in the sheet as discussed above. A vacuum is applied to the interior of the tool, and the sheet of textured material is pulled adjacent the fiber lay up such that the tops of the upraised portion contact the fiber lay up, but the valleys remain open to form a network of narrow, interconnected passageways through which resin is able to flow. Under the vacuum, resin is drawn first into the main feeder grooves and then into the valleys. From the valleys, the resin is able to fully impregnate the fiber material, flowing finally to the vacuum outlet channels around the perimeter. The resin is allowed sufficient time to cure. After curing, the part is removed from the tool.

[0034] In an alternative embodiment, the textured sheet can be used as a lid in conjunction with a conventional mold. The fiber lay up is placed against the mold surface. The textured sheet is placed over the fiber lay up and sealed to the mold in any suitable manner. Additional resin distribution media may need to be used adjacent the conventional mold surfaces. Resin impregnation occurs as discussed above.

[0035] The textured sheet can also be used as a master mold which is used to make tools from other materials, such as ceramics. The tool is then used as a mold in the resin impregnation process. In this case, the sheet comprises a negative of the tool; that is, the side of the sheet having the indentations is used to form the tool. The resulting tool has the configuration of the upraised portions separated by the valleys, which form a resin distribution medium as discussed above. A ceramic mold generally does not flex to collapse against the part under vacuum. In this case, a separate vacuum bag is used in conjunction with the mold, as is known in the art.

Claims

1. A method of forming a composite structure comprising:

providing a core having a peripheral surface and a feeder channel formed to lie across at least a portion of said peripheral surface of said core, said feeder channel having a first cross-sectional area;

providing a resin distribution network adjacent at least a portion of said core peripheral surface and in fluid communication with said feeder

- channel on said core peripheral surface, said resin distribution network comprising a network of a plurality of distribution channels adjacent said peripheral surface of said core extending from said feeder channel, each of said distribution channels having a second cross-sectional area smaller than the first cross-section area of the feeder channel;
- covering at least a portion of said core and said resin distribution network with a fiber material;
- providing a forming structure, at least a first portion of said forming structure comprising a mold and at least a further portion of said forming structure comprising a flexible portion collapsible under vacuum against an adjacent portion of said core;
- sealing said covered core and said fiber material in said forming structure;
- connecting a source of uncured resin directly to said feeder channel through said forming structure;
- connecting the interior of said forming structure to a vacuum outlet;
- forcing said uncured resin initially through said feeder channel and said resin distribution network to said vacuum outlet to fill the interior of said forming structure between said core and said forming structure to impregnate said fiber material;
- wherein said feeder channel and said distribution network are sized and arranged to allow said uncured resin to substantially, completely fill said fiber material covering said core prior to curing; and
- curing said resin to form a composite structure.
2. The method of claim 1, wherein said resin distribution network comprises a network of grooves formed in said surface of said core extending from said feeder channel, said grooves having a smaller cross-sectional area than said feeder channel.
 3. The method of claim 1, wherein said grooves are arranged transversely to said feeder channel.
 4. The method of claim 1, wherein at least a portion of said grooves circumscribe said core to form a loop beginning and terminating at said feeder channel.
 5. The method of claim 1, further comprising placing at least one connection fitting in said feeder channel prior to covering said core and said resin distribution network with a fiber material.
 6. The method of claim 5, wherein said step of connecting said source of uncured resin to said channel comprises forming a hole in said forming structure at said connection fitting and inserting a supply tube from said source into said connection fitting.
 7. The method of claim 1, further comprising providing a plurality of said cores, each having a peripheral surface and a feeder channel formed in said surface extending throughout a length of said core, and arranging said cores adjacent to each other to form a desired finished part.
 8. The method of claim 7, wherein said cores are arranged adjacent to each other with each of said feeder channels generally aligned.
 9. The method of claim 8, further comprising covering said adjacently arranged cores with a further fiber material prior to said step of placing in said mold.
 10. The method of claim 1, wherein said forming structure comprises a thin steel sheet.
 11. The method of claim 1, wherein said forming structure comprises a rigid mold and a flexible bag.
 12. The method of claim 1, wherein said forming structure comprises a rubber bag.
 13. The method of claim 1, wherein said forming structure comprises a silicone bag.
 14. The method of claim 1, wherein said forming structure comprises a thin composite sheet material.
 15. The method of Claim 1, wherein said feeder channel and said distribution network are sized and arranged to allow the resin to completely fill the fiber material covering the core prior to curing.
 16. The method of claim 1, wherein said core comprises a foam material.
 17. The method of claim 1, wherein said core comprises balsa wood.
 18. The method of claim 1, wherein said core comprises concrete.
 19. The method of claim 1, wherein said core comprises a block having a generally rectangular cross-section.
 20. The method of claim 1, wherein said core comprises a block having a generally triangular cross-section.
 21. The method of claim 1, wherein said core comprises a block having an arcuate face.
 22. The method of claim 1, wherein a plurality of feeder channels are formed to lie across at least a portion

of said peripheral surface of said core.

23. A method of forming a composite structure comprising:

providing a core having a peripheral surface and a feeder channel formed to lie across at least a portion of said peripheral surface of said core;
 providing a resin distribution network adjacent at least a portion of said core peripheral surface and in fluid communication with said feeder channel on said core peripheral surface;
 placing at least one connection fitting in said feeder channel;
 covering at least a portion of said core and said resin distribution network with a fiber material;
 placing said covered core in a mold;
 sealing said covered core in a bag against said mold;
 connecting a source of uncured resin directly to said feeder channel through said bag;
 connecting an interior of said bag to a vacuum outlet;
 forcing a substantial portion of said uncured resin through said feeder channel and from said feeder channel to said resin distribution network and from said distribution network through said fiber material and then to said vacuum outlet to impregnate said fiber material from said core outwardly toward said mold and said bag; and
 curing said resin to form a composite structure.

24. The method of claim 23, wherein said resin distribution network comprises a network of grooves formed in said surface of said core extending from said feeder channel, said grooves having a smaller cross-sectional area than said feeder channel.

25. The method of claim 24, wherein said grooves are arranged transversely to said feeder channel.

26. The method of claim 24, wherein at least a portion of said grooves circumscribe said core to form a loop beginning and terminating at said feeder channel.

27. The method of claim 24, further comprising placing at least one connection fitting in said feeder channel prior to covering said core and said resin distribution network with a fiber material.

28. The method of claim 27, wherein said step of connecting said source of uncured resin to said channel comprises puncturing said bag at said connection fitting and inserting a supply tube from said source into said connection fitting.

29. The method of claim 23, further comprising providing a plurality of said cores, each having a peripheral surface and a feeder channel formed in said surface extending throughout a length of said core, and arranging said cores adjacent to each other to form a desired finished part.

30. The method of claim 29, wherein said cores are arranged adjacent to each other with each of said feeder channels generally aligned.

31. The method of claim 29, further comprising covering said adjacently arranged cores with a further fiber material prior to said step of placing in said mold.

32. The method of claim 23, wherein said feeder channel and said distribution network are sized and arranged to allow the resin to completely fill the fiber material covering the core prior to curing.

33. The method of claim 23, wherein said core comprises a foam material.

34. The method of claim 23, wherein said core comprises balsa wood.

35. The method of claim 23, wherein said core comprises concrete.

36. The method of claim 23, wherein said core comprises a block having a generally rectangular cross-section.

37. The method of claim 23, wherein said core comprises a block having a generally triangular cross-section.

38. The method of claim 23, wherein said core comprises a block having an arcuate face.

39. The method of claim 23, wherein a plurality of feeder channels are formed to lie across at least a portion of said peripheral surface of said core.

Patentansprüche

1. Verfahren zur Bildung einer Verbundstruktur, mit den folgenden Schritten:

- Vorsehen eines Kerns mit einer Umfangsfläche und einem Zuführkanal, der über wenigstens einem Teil der Umfangsfläche des Kerns liegend ausgebildet ist, wobei der Zuführkanal eine erste Querschnittsfläche aufweist;
- Vorsehen eines Harzverteilungsnetzwerks neben wenigstens einem Bereich der Kernum-

- fangsfläche und in Fluidverbindung mit dem Zuführkanal auf der Kernumfangsfläche, wobei das Harzverteilungsnetzwerk ein Netzwerk aus mehreren Verteilerkanälen nahe der Umfangsfläche des Kerns aufweist, die sich vom Zuführkanal aus erstrecken, wobei jeder der Verteilerkanäle eine zweite Querschnittsfläche hat, die kleiner als die erste Querschnittsfläche des Zuführkanals ist;
- Bedecken wenigstens eines Teils des Kerns und des Harzverteilungsnetzwerks mit einem Fasermaterial;
 - Vorsehen einer Formungsstruktur, wobei wenigstens ein erster Teil der Formungsstruktur eine Form und wenigstens ein weiterer Teil der Formungsstruktur einen flexiblen Teil aufweist, der unter Vakuum gegen einen benachbarten Bereich des Kerns faltbar ist;
 - Abdichten des abgedeckten Kerns und des Fasermaterials in der Formungsstruktur;
 - Verbinden einer Quelle ungehärteten Harzes unmittelbar mit dem Zuführkanal durch die Formungsstruktur;
 - Verbinden des Innenraums der Formungsstruktur mit einem Vakuumauslaß;
 - Drücken des ungehärteten Harzes zunächst durch den Zuführkanal und das Harzverteilungsnetzwerk zu dem Vakuumauslaß, um den Innenraum der Formungsstruktur zwischen dem Kern und der Formungsstruktur zum Imprägnieren des Fasermaterials zu füllen;
 - wobei der Zuführkanal und das Verteilungsnetzwerk derart bemessen und angeordnet sind, daß sie ein im wesentlichen vollständiges Füllen des den Kern bedeckenden Fasermaterials mit dem ungehärteten Harz vor dem Aushärten ermöglichen; und
 - Aushärten des Harzes zur Bildung einer Verbundstruktur.
2. Verfahren nach Anspruch 1, bei dem das Harzverteilungsnetzwerk ein Netzwerk von Rillen aufweist, die sich von dem Zuführkanal aus erstreckend in der Oberfläche des Kerns ausgebildet sind, wobei die Rillen einen kleineren Querschnittsfläche haben als der Zuführkanal.
 3. Verfahren nach Anspruch 1, bei dem die Rillen quer zum Zuführkanal angeordnet sind.
 4. Verfahren nach Anspruch 1, bei dem wenigstens ein Teil der Rillen den Kern umgrenzen, um eine Schleife zu bilden, die am Zuführkanal beginnt und endet.
 5. Verfahren nach Anspruch 1, ferner mit dem Schritt des Anordnens wenigstens eines Verbindungsfitings in dem Zuführkanal vor dem Bedecken des Kerns und des Harzverteilungsnetzwerks mit einem Fasermaterial.
 6. Verfahren nach Anspruch 5, bei dem der Schritt des Verbindens der Quelle ungehärteten Harzes mit dem Kanal das Bilden eines Lochs in der Formungsstruktur an dem Verbindungsfitting und das Einführen eines Versorgungsschlauchs von der Quelle in den Verbindungsfitting umfaßt.
 7. Verfahren nach Anspruch 1, ferner mit dem Vorsehen mehrerer Kerne, von denen jeder eine Umfangsfläche und einen in der Umfangsfläche ausgebildeten Zuführkanal, der sich über die Länge des Kerns erstreckt, aufweist, und dem Anordnen der Kerne nebeneinander zur Bildung eines gewünschten Fertigteils.
 8. Verfahren nach Anspruch 7, bei dem die Kerne nebeneinander angeordnet werden, wobei jeder der Zuführkanäle im wesentlichen ausgerichtet ist.
 9. Verfahren nach Anspruch 8, ferner mit dem Schritt des Bedeckens der nebeneinander angeordneten Kerne mit einem weiteren Fasermaterial vor dem Schritt des Anordnens in der Form.
 10. Verfahren nach Anspruch 1, bei dem die Formungsstruktur ein dünnes Stahlblech aufweist.
 11. Verfahren nach Anspruch 1, bei dem die Formungsstruktur eine starre Form und einen flexiblen Beutel aufweist.
 12. Verfahren nach Anspruch 1, bei dem die Formungsstruktur einen Gummibeutel aufweist.
 13. Verfahren nach Anspruch 1, bei dem die Formungsstruktur einen Silikonbeutel aufweist.
 14. Verfahren nach Anspruch 1, bei dem die Formungsstruktur ein dünnes Verbundbahnmaterial aufweist.
 15. Verfahren nach Anspruch 1, bei dem der Zuführkanal und das Verteilungsnetzwerk derart bemessen und angeordnet sind, daß sie ein vollständiges Füllen des den Kern bedeckenden Fasermaterials mit dem Harz vor dem Aushärten ermöglichen.
 16. Verfahren nach Anspruch 1, bei dem der Kern ein

Schaummaterial aufweist.

17. Verfahren nach Anspruch 1, bei dem der Kern Bal-saholz aufweist.

18. Verfahren nach Anspruch 1, bei dem der Kern Be-ton aufweist.

19. Verfahren nach Anspruch 1, bei dem der Kern einen Block mit im wesentlichen rechteckigem Quer-schnitt aufweist.

20. Verfahren nach Anspruch 1, bei dem der Kern einen Block mit im wesentlichen dreieckigem Querschnitt aufweist.

21. Verfahren nach Anspruch 1, bei dem der Kern einen Block mit einer gebogenen Seite aufweist.

22. Verfahren nach Anspruch 1, bei dem mehrere Zu-führkanäle über zumindest einem Teil der Umfangs-fläche des Kerns liegend ausgebildet sind.

23. Verfahren zum Bilden einer Verbundstruktur, mit den folgenden Schritten:

- Vorsehen eines Kerns mit einer Umfangsfläche und einem Zuführkanal, der über wenigstens einem Teil der Umfangsfläche des Kerns lie-gend ausgebildet ist;
- Vorsehen eines Harzverteilungsnetzwerks ne-ben wenigstens einem Bereich der Kernum-fangsfläche und in Fluidverbindung mit dem Zuführkanal auf der Kernumfangsfläche;
- Anordnen wenigstens eines Verbindungsfit-tings in dem Zuführkanal;
- Bedecken wenigstens eines Teils des Kerns und des Harzverteilungsnetzwerks mit einem Fasematerial;
- Anordnen des bedeckten Kerns in eine Form;
- Abdichten des bedeckten Kerns gegenüber der Form in einem Beutel;
- Verbinden einer Quelle ungehärteten Harzes unmittelbar mit dem Zuführkanal durch den Beutel;
- Verbinden des Innenraums des Beutels mit ei-nem Vakuumauslaß;
- Drücken eines erheblichen Teils des ungehär-teten Harzes durch den Zuführkanal und aus dem Zuführkanal zu dem Harzverteilungsnetz-

werk und von dem Harzverteilungsnetzwerk durch das Fasematerial und anschließend zum Vakuumauslaß, um das Fasematerial vom Kern aus nach außen in Richtung der Form und des Beutels zu imprägnieren; und

- Aushärten des Harzes zur Bildung einer Ver-bundstruktur.

24. Verfahren nach Anspruch 23, bei dem das Harzver-teilungsnetzwerk ein Netzwerk von Rillen aufweist, die sich von dem Zuführkanal aus erstreckend in der Oberfläche des Kerns ausgebildet sind, wobei die Rillen einen kleinere Querschnittsfläche haben als der Zuführkanal.

25. Verfahren nach Anspruch 24, bei dem die Rillen quer zum Zuführkanal angeordnet sind.

26. Verfahren nach Anspruch 24, bei dem wenigstens ein Teil der Rillen den Kern umgrenzen, um eine Schleife zu bilden, die am Zuführkanal beginnt und endet.

27. Verfahren nach Anspruch 24, ferner mit dem Schritt des Anordnens wenigstens eines Verbindungsfit-tings in dem Zuführkanal vor dem Bedecken des Kerns und des Harzverteilungsnetzwerks mit einem Fasematerial.

28. Verfahren nach Anspruch 27, bei dem der Schritt des Verbindens der Quelle ungehärteten Harzes mit dem Kanal das Punktlernen des Beutels an dem Verbindungsfitting und das Einführen eines Versor-gungsschlauchs von der Quelle in den Verbin-dungsfitting umfaßt.

29. Verfahren nach Anspruch 27, ferner mit dem Vor-sehen mehrerer Kerne, von denen jeder eine Um-fangsfläche und einen in der Umfangsfläche aus-gebildeten Zuführkanal, der sich über die Länge des Kerns erstreckt, aufweist, und dem Anordnen der Kerne nebeneinander zur Bildung eines ge-wünschten Fertigteils.

30. Verfahren nach Anspruch 29, bei dem die Kerne ne-beneinander angeordnet werden, wobei jeder der Zuführkanäle im wesentlichen ausgerichtet ist.

31. Verfahren nach Anspruch 29, ferner mit dem Schritt des Bedeckens der nebeneinander angeordneten Kerne mit einem weiteren Fasematerial vor dem Schritt des Anordnens in der Form.

32. Verfahren nach Anspruch 23, bei dem der Zuführ-kanal und das Verteilungsnetzwerk derart bemes-sen und angeordnet sind, daß sie ein vollständiges Füllen des den Kern bedeckenden Fasematerials

mit dem Harz vor dem Aushärten ermöglichen.

33. Verfahren nach Anspruch 23, bei dem der Kern ein Schaummaterial aufweist.

5

34. Verfahren nach Anspruch 23, bei dem der Kern Bal-saholz aufweist.

35. Verfahren nach Anspruch 23, bei dem der Kern Be-ton aufweist.

10

36. Verfahren nach Anspruch 23, bei dem der Kern ei-nen Block mit im wesentlichen rechteckigem Quer-schnitt aufweist.

15

37. Verfahren nach Anspruch 23, bei dem der Kern ei-nen Block mit im wesentlichen dreieckigem Quer-schnitt aufweist.

38. Verfahren nach Anspruch 23, bei dem der Kern ei-nen Block mit einer gebogenen Seite aufweist.

20

39. Verfahren nach Anspruch 23, bei dem mehrere Zu-führkanäle über zumindest einem Teil der Umfangs-fläche des Kerns liegend ausgebildet sind.

25

Revendications

1. Procédé de formation de structure composite com-prenant les étapes consistant à :

30

proposer un noyau ayant une surface périphé-rique et un canal d'alimentation formé afin de reposer sur au moins une partie de ladite sur-face périphérique dudit noyau, ledit canal d'ali-mentation ayant une première section transversale ;

proposer un réseau de distribution de résine adjacent à au moins une partie de ladite surface périphérique du noyau et en communication li-quide avec ledit canal d'alimentation sur ladite surface périphérique du noyau, ledit réseau de distribution de résine comprenant un réseau d'une pluralité de canaux d'alimentation adja-cents à ladite surface périphérique dudit noyau s'étendant dudit canal d'alimentation, chacun desdits canaux d'alimentation ayant une se-conde section transversale inférieure à la pre-mière section transversale du canal d'alimentation ;

35

recouvrir au moins une partie dudit noyau et du-dit réseau de distribution de résine à l'aide d'un matériau en fibre ;

40

proposer une structure de formation, au moins une première partie de ladite structure de for-mation comprenant un moule et au moins une partie supplémentaire de ladite structure de for-

45

50

55

mation comprenant une partie flexible pliable par le vide placé contre une partie adjacente dudit noyau ;
sceller ledit noyau recouvert et ledit matériau en fibre dans ladite structure de formation ;
raccorder la source de la résine non traitée di-rectement au canal d'alimentation au travers de ladite structure de formation ;
raccorder l'intérieur de ladite structure de for-mation à une sortie aspirante ;
forcer initialement ladite résine non traitée au travers dudit canal d'alimentation et dudit ré-seau de distribution de résine vers ladite sortie aspirante afin de remplir l'intérieur de ladite structure de formation entre ledit noyau et ladi-te structure de formation afin d'imprégner ledit matériau en fibre.

2. Procédé selon la revendication 1, dans laquelle le réseau de distribution de résine comprend un ré-seau de rainures formées dans ladite surface dudit noyau s'étendant dudit canal d'alimentation, lesdi-tes rainures ayant une section transversale infé-rieure au canal d'alimentation.

3. Procédé selon la revendication 1, dans laquelle les-dites rainures sont placées de manière transversale par rapport au dit canal d'alimentation.

4. Procédé selon la revendication 1 dans laquelle au moins une partie desdites rainures circonscrivent ledit noyau pour former un anneau commençant et se terminant au dit canal d'alimentation.

5. Procédé selon la revendication 1, comprenant en outre le placement d'au moins une fixation de rac-cordement dans ledit canal d'alimentation avant de recouvrir ledit noyau et ledit réseau de distribution de résine avec un matériau en fibre.

6. Procédé selon la revendication 5, dans laquelle la-dite étape de raccordement de ladite source de ré-sine non traitée au dit canal comprend la formation d'un trou dans ladite structure de formation à ladite fixation de raccordement et l'insertion d'un tube d'approvisionnement à partir de ladite source dans ladite fixation de raccordement.

7. Procédé selon la revendication 1, comprenant en outre la proposition d'une pluralité desdits noyaux, ayant chacun une surface périphérique et un canal d'alimentation formé dans ladite surface s'étendant sur la longueur dudit noyau et la disposition desdits noyaux de manière adjacente l'un par rapport à l'autre pour former la pièce finie souhaitée.

8. Procédé selon la revendication 7, dans laquelle les-dits noyaux sont disposés de manière adjacente

l'un par rapport à l'autre avec chacun desdits canaux d'alimentation généralement alignés.

9. Procédé selon la revendication 8, comprenant en outre le recouvrement desdits noyaux disposés de manière adjacente par un autre matériau en fibre avant ladite étape de placement dans ledit moule. 5
10. Procédé selon la revendication 1, dans laquelle ladite structure de formation comprend une fine feuille d'acier. 10
11. Procédé selon la revendication 1, dans laquelle ladite structure de formation comprend un moule rigide et un sac flexible. 15
12. Procédé selon la revendication 1, dans laquelle ladite structure de formation comprend un sac en caoutchouc. 20
13. Procédé selon la revendication 1, dans laquelle ladite structure de formation comprend un sac en silicone. 20
14. Procédé selon la revendication 1, dans laquelle ladite structure de formation comprend une fine feuille de matériau composite. 25
15. Procédé selon la revendication 1, dans laquelle ledit canal d'alimentation et ledit réseau de distribution sont calibrés et disposés de manière à permettre à la résine de remplir complètement le matériau en fibre couvrant le noyau avant de durcir. 30
16. Procédé selon la revendication 1, dans laquelle ledit noyau comprend un matériau alvéolaire. 35
17. Procédé selon la revendication 1, dans laquelle ledit noyau comprend du balsa. 40
18. Procédé selon la revendication 1, dans laquelle ledit noyau comprend du béton. 40
19. Procédé selon la revendication 1, dans laquelle ledit noyau comprend un bloc ayant une section transversale en général rectangulaire. 45
20. Procédé selon la revendication 1, dans laquelle ledit noyau comprend un bloc ayant en général une section transversale triangulaire. 50
21. Procédé selon la revendication 1, dans laquelle ledit noyau comprend un bloc ayant une face arquée.
22. Procédé selon la revendication 1, dans laquelle une pluralité de canaux d'alimentation sont formés pour reposer sur au moins une partie de ladite surface périphérique dudit noyau. 55

23. Procédé de formation de structure composite comprenant les étapes consistant à :

proposer un noyau ayant une surface périphérique et un canal de distribution formé afin de reposer sur au moins une partie de ladite surface périphérique dudit noyau ;
 proposer un réseau de distribution de résine adjacent à au moins une partie de la surface périphérique dudit noyau et en communication liquide avec ledit canal d'alimentation sur ladite surface périphérique du noyau ;
 placer au moins une fixation de raccordement dans ledit canal d'alimentation ;
 recouvrir au moins une partie dudit noyau et dudit réseau de distribution de résine à l'aide d'un matériau en fibre ;
 sceller ledit noyau recouvert dans un sac contre ledit moule ;
 raccorder la source de la résine non traitée directement au dit canal d'alimentation à travers ledit sac ;
 raccorder un intérieur dudit sac de production à une sortie aspirante ;
 forcer une partie substantielle de ladite résine non traitée au travers dudit canal d'alimentation et à partir dudit canal d'alimentation vers ledit réseau de distribution de résine et à partir dudit réseau de distribution au travers dudit matériau en fibre et enfin vers ladite sortie aspirante afin d'imprégner ledit matériau en fibre à partir dudit noyau de l'extérieur vers ledit moule et ledit sac ; et
 traiter ladite résine pour former une structure composite.

24. Procédé selon la revendication 23, dans laquelle ledit réseau de distribution de résine comprend un réseau de rainures formées dans ladite surface dudit noyau s'étendant dudit canal d'alimentation, lesdites rainures ayant une section transversale inférieure au canal d'alimentation.

25. Procédé selon la revendication 24, dans laquelle lesdites rainures sont disposées de manière transversale par rapport au dit canal d'alimentation.

26. Procédé selon la revendication 24, dans laquelle au moins une partie desdites rainures circonscrivent ledit noyau afin de former un cercle commençant et s'achevant au dit canal d'alimentation.

27. Procédé selon la revendication 24, comprenant en outre le placement d'au moins une fixation de raccordement dans ledit canal d'alimentation avant de recourir ledit noyau et ledit réseau de distribution de résine à l'aide d'un matériau en fibre.

28. Procédé selon la revendication 27, dans laquelle ladite étape de raccordement de ladite source de résine non traitée au dit canal comprend une perforation dudit sac à ladite fixation de raccordement et l'insertion d'un tube d'approvisionnement à partir de ladite source dans ladite fixation de raccordement. 5
29. Procédé selon la revendication 23, comprenant en outre la proposition de plusieurs desdits noyaux, ayant chacun une surface périphérique et un canal d'alimentation formé dans ladite surface s'étendant le long dudit noyau, et le placement desdits noyaux de manière adjacente les uns par rapport aux autres afin de former la pièce finie souhaitée. 10 15
30. Procédé selon la revendication 29, dans laquelle lesdits noyaux sont placés de manière adjacente les uns par rapport aux autres avec chacun desdits canaux d'alimentation généralement alignés. 20
31. Procédé selon la revendication 29, comprenant en outre l'étape consistant à recouvrir lesdits noyaux disposés de manière adjacente avec un autre matériau en fibre avant ladite étape du placement dans ledit moule. 25
32. Procédé selon la revendication 23, dans laquelle ledit canal d'alimentation et ledit réseau de distribution sont calibrés et disposés de manière à permettre à la résine de remplir complètement le matériau en fibre couvrant le noyau avant de traiter. 30
33. Procédé selon la revendication 23, dans laquelle ledit noyau comprend un matériau alvéolaire. 35
34. Procédé selon la revendication 23, dans laquelle ledit noyau comprend du balsa. 40
35. Procédé selon la revendication 23, dans laquelle ledit noyau comprend du béton. 45
36. Procédé selon la revendication 23, dans laquelle ledit noyau comprend un bloc ayant une section transversale en général rectangulaire. 50
37. Procédé selon la revendication 23, dans laquelle ledit noyau comprend un bloc ayant une section transversale en général triangulaire. 55
38. méthode selon la revendication 23, dans laquelle ledit noyau comprend un bloc ayant une face arquée.
39. Procédé selon la revendication 23, dans laquelle une pluralité de canaux d'alimentation sont formés pour reposer sur au moins une partie de ladite surface périphérique dudit noyau.

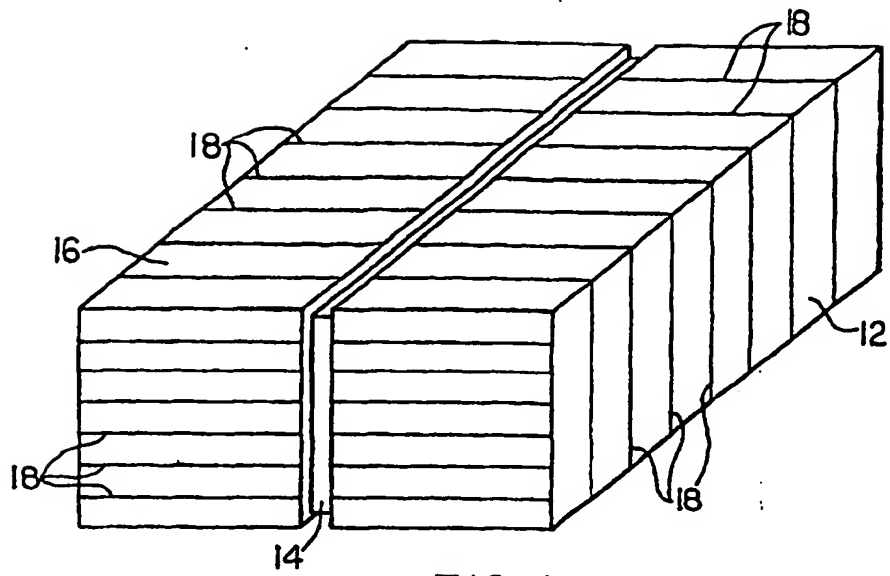


FIG. 1

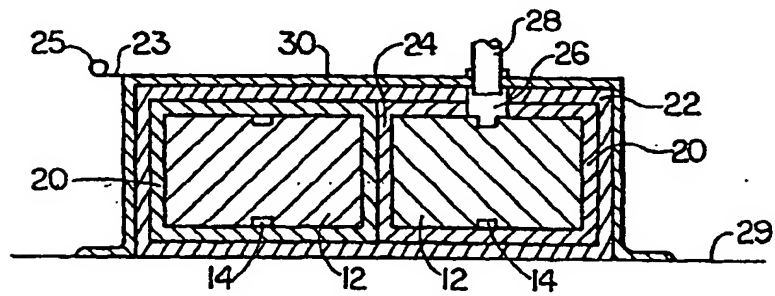


FIG. 2

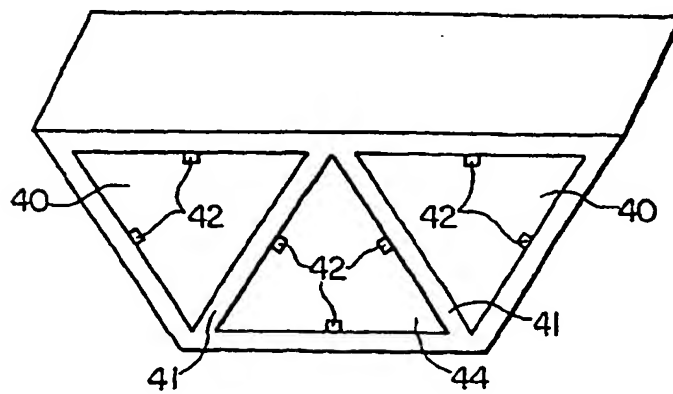


FIG. 3

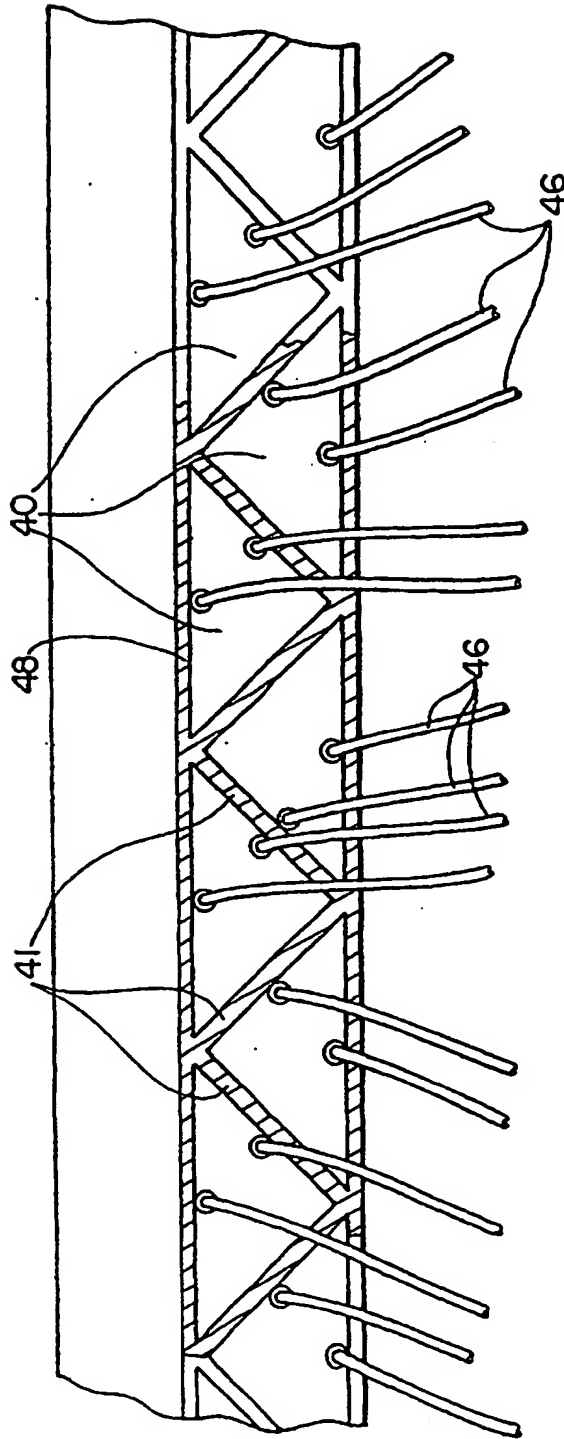


FIG. 4

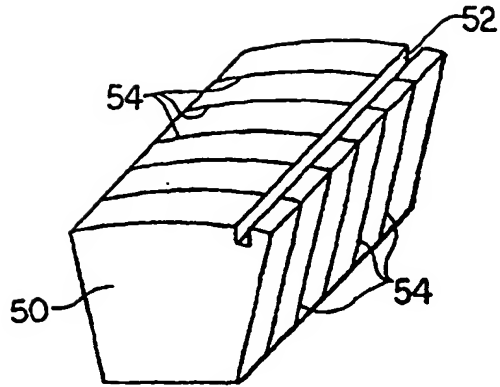


FIG. 5

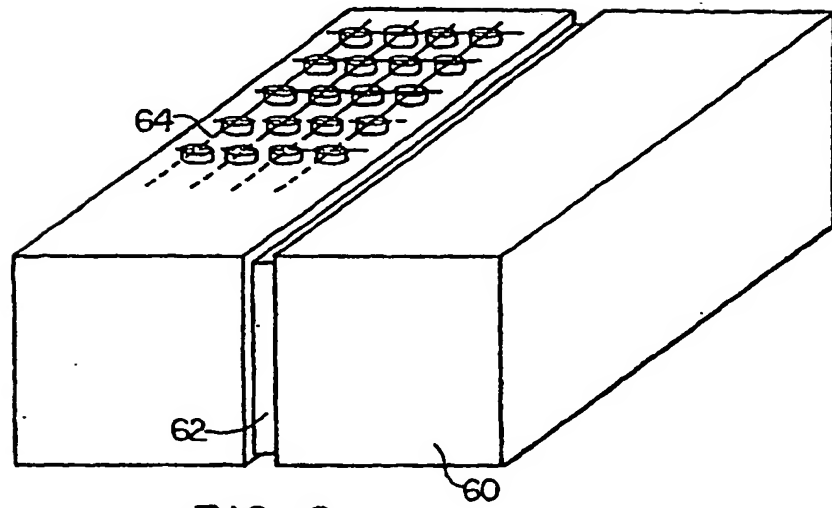


FIG. 6

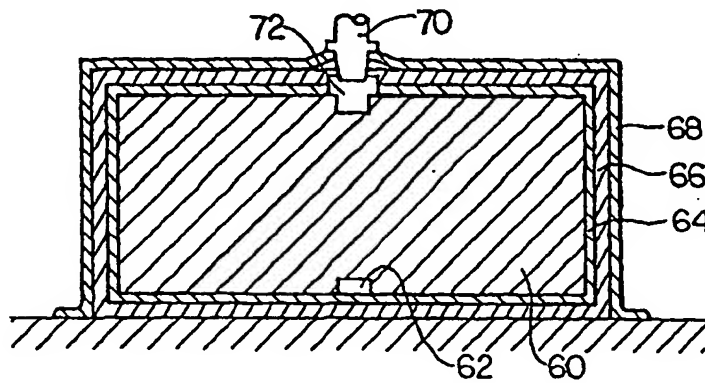


FIG. 7

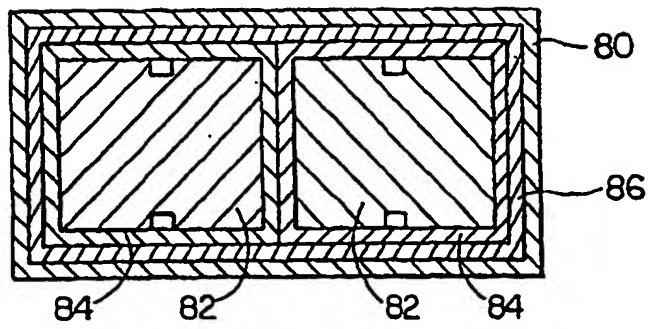


FIG. 8

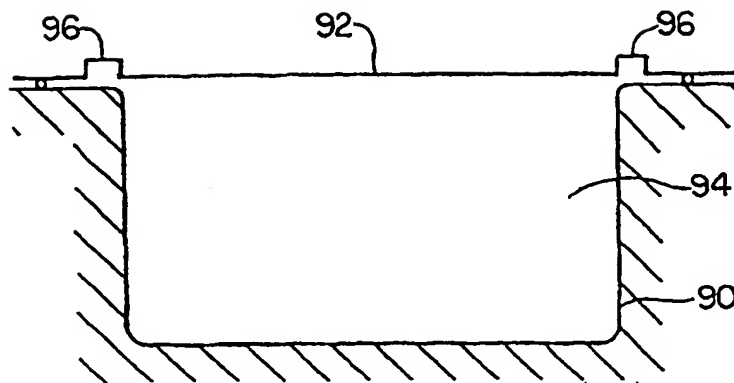


FIG. 9

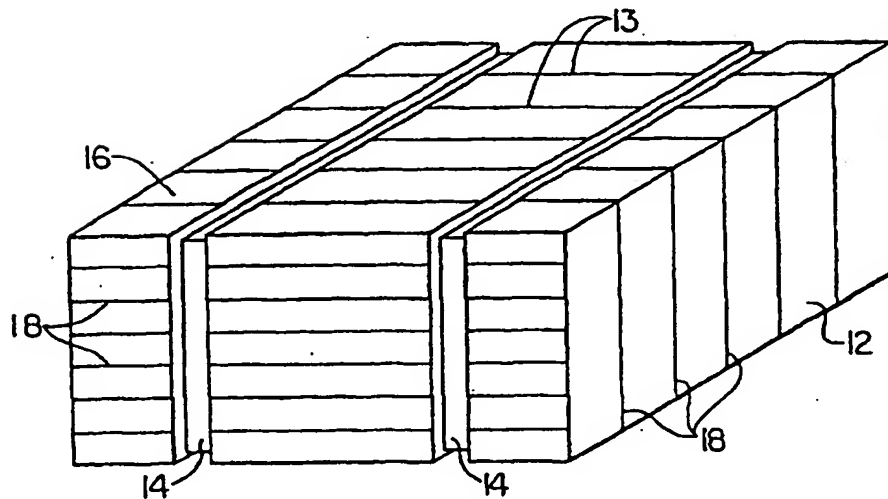


FIG. 10

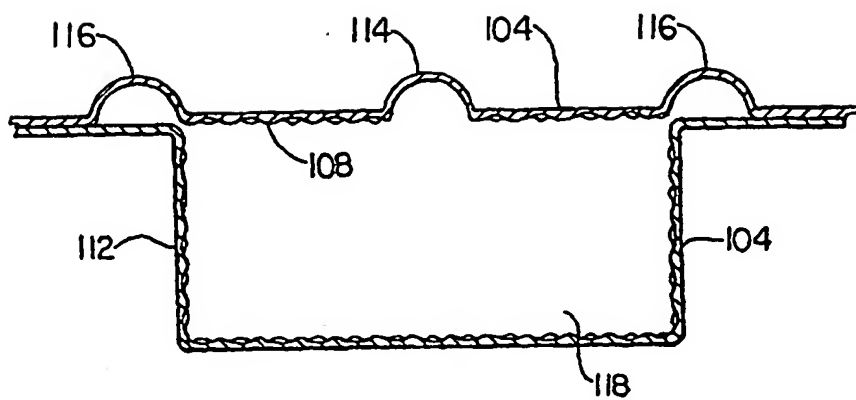


FIG. 11

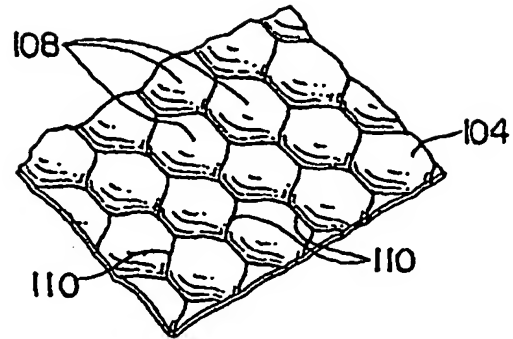


FIG. 13

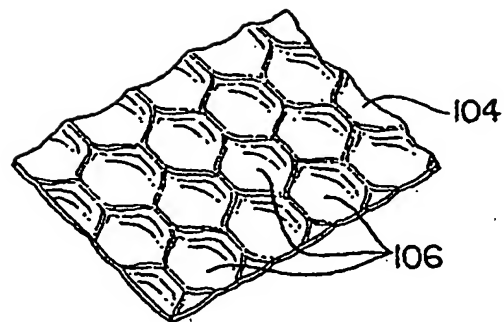


FIG. 12